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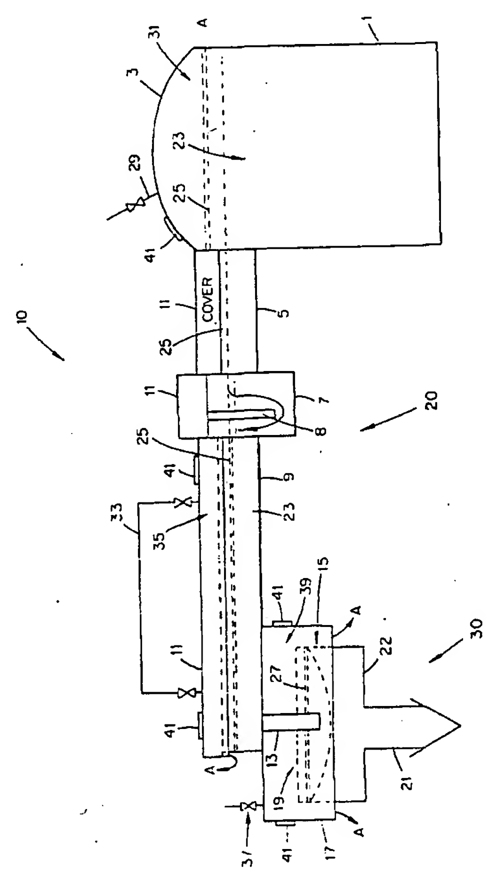
(54) **Method and apparatus for reducing moisture and hydrogen pick up of hygroscopic molten salts during aluminum-lithium alloy ingot casting**

(57) A method and an apparatus for melting and casting aluminum-lithium alloy ingots enhance ingot quality by supplying an inert gas such as argon to ambient atmospheric air (31, 35) during melting and casting. Argon is supplied to one or more covers (3, 11, 17) of the furnace (1), pour trough (9) and casting station (30) to reduce moisture pick up by hygroscopic molten salt baths (25, 27) used during the melting and casting steps.



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Descripti n

Field of the Invention

The present invention is directed to a method and apparatus for reducing moisture pick up of hygroscopic molten salts which are used during aluminum-lithium alloy casting and, in particular, to the use of an inert gas to control humidity levels of the atmosphere in the casting environment.

Background Art

In the aerospace and aircraft industry, the use of aluminum-lithium alloys for component parts of aircraft or the like has steadily increased. Aluminum-lithium alloys are selected in these applications for reasons of their material properties such as low density, high strength, high fracture toughness and high modulus of elasticity. Using these alloys in aircraft applications effectively reduces the overall weight of the aircraft without any loss in mechanical or other physical properties.

Although aluminum-lithium alloys are desirable for use in aircraft components, their manufacture is not without drawbacks and disadvantages. During casting of aluminum-lithium alloys, the reactivity of the alloy because of its lithium makes production difficult. That is, any molten lithium on the surface of the aluminum-lithium bath may burn on contact with air causing loss of the lithium, flaming, smoking and inaccessibility to the melt. The molten lithium also tends to attract hydrogen from the atmosphere, particularly water vapor in the atmosphere. The hydrogen can be absorbed into the molten bath and ingots cast therefrom can exhibit higher porosity levels and undesirable mechanical properties. The prior art has proposed various solutions in response to the disadvantages noted above concerning the casting of aluminum-lithium alloys. U.K. Patent Application No. 2,129,345 to Enright teaches the use of an inert gas atmosphere which blankets the surface of the molten metal and isolates it from atmospheric air.

Other solutions include the use of a flux cover over the molten metal surface. In the Enright U.K. patent application referenced above, a flux is maintained over the exposed molten metal surface and over the inert gas-shielded peripheral region. The flux can be a halide-type flux such as lithium chloride.

It has also been proposed to melt and cast aluminum-lithium alloys under a molten salt cover bath without an inert gas shield. However, due to the hygroscopic nature of these types of fluxes, it has been observed that cast ingot quality has suffered when casting during hot and humid weather conditions. The ingots cast during these conditions may exhibit undesirable levels of hydrogen in the cast product. It is believed that, due to the hygroscopic nature of the molten salt bath, moisture in the surrounding atmosphere is picked up by the bath, this moisture acting as a source of the hydrogen in the cast product. In view of this seasonal problem, a need has developed to provide a method and apparatus which permits effective aluminum-lithium alloy ingot casting under all weather conditions while still utilizing only a molten salt bath during melting and casting of the aluminum-lithium alloys. In response to this need, the present invention provides a method and apparatus for reducing the moisture pick up of a hygroscopic molten salt bath used in aluminum-lithium alloy ingot casting. By reducing the moisture pick up by the hygroscopic molten salts, the aluminum-lithium alloy ingot cast quality is improved through reduction in residual hydrogen levels.

Summary of the Invention

Accordingly, it is a first object of the present invention to provide an improved method for casting aluminum-lithium alloys using a molten salt bath.

Another object of the present invention is to control the moisture pick up of hygroscopic molten salt baths used during aluminum-lithium alloy casting.

It is further object of the present invention to provide improved cast ingot quality by reducing residual hydrogen levels in the cast product.

A still further object of the present invention is to provide an apparatus for casting aluminum-lithium alloy ingots which permits control of moisture in the atmospheric air present in the casting environment.

Other objects and advantages of the present invention will become apparent as a description thereof proceeds.

In satisfaction of the foregoing objects and advantages, the present invention is an improvement over methods using molten salt baths during the casting of aluminum-lithium alloy ingots or slabs. According to the invention, an effective amount of an inert gas is supplied to a moisture-containing atmospheric gas in contact with the molten salt bath to reduce salt bath moisture pick up. Preferably, the molten salt bath is utilized during at least one of melting and/or alloying of the aluminum-lithium alloy in a furnace, transferring of the molten aluminum-lithium alloy from a furnace to a casting station, and casting of the aluminum-lithium alloy. More preferably, argon is used as the inert gas and is supplied after initiation of the casting step. Argon gas is supplied in amounts which reduce the relative humidity of the atmospheric air in contact with the molten salt bath, preferably reducing the relative humidity by at least 5% and more preferably by 10 to 20%.

The present invention also provides improvements in known apparatus used for melting and/or casting of aluminum-lithium alloys. According to the invention, means are provided for supplying an effective amount of an inert gas to moisture-containing atmospheric gas in contact with the molten salt bath covering a molten aluminum-lithium bath. The means for supplying the inert gas reduces moisture pick up by the molten salt bath

by reducing the moisture content of the atmospheric gas. Preferably, the means for supplying further comprises a cover over at least one of the melting furnace, the transfer arrangement between the furnace and the casting station and the casting station. The inert gas is supplied to the covers via piping to mix with the atmospheric gas thereunder. The covers are vented to permit purging of the atmospheric gas to reduce the moisture content of the atmospheric gas - inert gas mixture.

The inventive method also provides an improved cast ingot which exhibits reduced levels of hydrogen as compared to ingots cast during hot and humid weather conditions.

Brief Description of the Drawings

Reference is now made to the drawing of the invention wherein the sole figure is a schematic representation of the inventive method and apparatus.

Description of the Preferred Embodiments

With reference to the sole figure, the inventive method and apparatus are generally designated by the reference numeral 10 and seen to include a melt and alloying furnace 1 having a cover 3 thereover, a transfer station 20 and a casting station 30. The transfer station 20 includes trough 5, filter 7 and pour trough 9. The pour trough 9 includes a cover 11 and a downspout 13.

The downspout 13 channels molten metal into the casting mold 15. The casting station 30 also includes a casting cover 17 which covers the ingot head 19. The starter bar 22 moves downwardly by the hydraulic drive 21 for casting initiation.

In operation, an aluminum-lithium alloy 23 is provided in the furnace 1. The aluminum-lithium alloy can be derived from scrap or alloyed by the proper combination of alloying components. The melt 23 then travels through the trough 5, filter 7, pour trough 9 and downspout 13 to the casting mold 15. Once the metal in the casting mold 15 is at the proper level, ingot formation is initiated by downward movement of the starter bar 22.

Preferably, the molten bath 23 has a molten salt bath cover 25 thereover. The salt bath cover 25 can be initiated in the melt and alloying furnace 1 so that it flows with the molten metal into the pour trough 9. The baffle 8 in the filter forces the aluminum-lithium alloy to be submerged, leaving the molten salt cover intact on the metal surface. Alternatively, as shown in the sole figure, only the molten metal 23 flows through trough 5 and filter 7 to the pour trough 9. In this mode the salt bath 25 is either not used or reinitiated in the pour trough 9. Another molten salt bath 27 can be maintained on the ingot head 19 during casting.

It should be understood that any molten salt bath can be used as a cover during the casting sequence, with a lithium chloride containing salt composition being preferred. More preferably, the salt bath is a mixture of lithium chloride and another salt selected from the group of potassium chloride, lithium fluoride and sodium chloride as disclosed in United States Patent Application Serial No. 08/034,329, filed March 22, 1993, which is incorporated herein by reference. The molten salt bath 25 as described above can be initiated in one or more of the alloying furnace 1, the pour trough 9 or the casting station 30.

In its broadest embodiment, the inventive method and apparatus include the provision for injection or supply of an inert gas to at least one of the molten alloying furnace 1, pour trough 9 or casting station 30. The inert gas is supplied during these steps or in these apparatus as a means to reduce the moisture content of atmospheric air in these casting environment zones to reduce moisture pick up by the hygroscopic molten salt baths 25 or 27. Injection or supply of the inert gas effectively dilutes the atmospheric air or reduces its relative humidity level to a point where the moisture pick up by the hygroscopic molten salt is vastly reduced or eliminated. With this supply of inert gas, more successful aluminum-lithium alloy ingot casting can be achieved using just a molten salt bath cover even during the hottest and most humid weather conditions. The technology required to establish a "tight" inert gas cover over the entire system is thus avoided, as taught by others, the salt bath cover provides the protection of the aluminum-lithium alloy from surface oxidation, hydrogen pickup, losses, etc; while the inert cover protects the molten salts from typically non-controllable ambient weather conditions.

Although any inert gas can be used to reduce the level of moisture in the atmospheric gas in the various casting locales, argon gas is preferred. Even more preferred is argon gas with less than 5 ppm moisture.

With reference again to the sole figure, argon gas is supplied to the melt and alloying furnace cover 3 via piping 29. With this supply of argon gas, the relative humidity level of the atmospheric gas 31 under the cover 3 is reduced to a level which does not adversely affect the quality of the molten aluminum-lithium alloy 23.

Likewise, argon gas can be supplied via piping 33 to the pour trough cover 11. With this supply of argon gas, the moisture in the atmospheric air 35 under the cover 11 is reduced for more effective ingot casting.

A similar piping arrangement 37 provides argon gas to the casting station cover 17 to effectively reduce the humidity levels in the atmospheric air thereunder.

Each of the covers 3, 11 and 17 are configured over their respective molten aluminum-lithium alloy containers to allow venting of moisture-laden gas. Venting of this gas is represented by the letter A for each of the covers 3, 11 and 17.

Although the argon gas can be supplied during melting and/or alloying of the bath 23, it is preferably initiated at the onset of casting or downward movement of the starter bar 22. The argon gas can be supplied by any conventional source and controlled using conven-

tional sensing and controller arrangements.

Supplying the argon gas into one or more of the covers 3, 11 and 17, effectively lowers the percentage of water vapor in the atmospheric gas in contact with the exposed molten salt bath surface under covers 3, 11 and 17. This lowering of the water vapor percentage occurs principally as a result of the argon gas displacing a portion of the moisture-laden atmospheric gas under the covers. Water vapor removal by this displacement lowers the relative humidity of the atmospheric air in contact with the molten salt bath and its dew point. Thus, the molten salt bath is more effective in protecting the reactive aluminum-lithium molten metal during casting.

Tonnage-based experiments have demonstrated that supply of argon gas under the various covers wherein a 10 to 20% reduction in relative humidity is achieved resulted in improved ingot quality as measured by lower hydrogen content in the ingot.

Although a 10 to 20% reduction in relative humidity in this test work demonstrated unexpected and improved ingot quality, other reductions, e.g. as low as 5% or in excess of 20%, may be acceptable given the particular weather conditions. The reduction in humidity equates to a specific and effective amount of argon to be supplied under a given cover. The effective amount is considered to be that amount which when supplied in a given cover will reduce the moisture content of the atmospheric air thereunder to a level of moisture which does not adversely affect the molten salt bath or aluminum-lithium alloy. It is within the skill of the artisan given the knowledge of existing weather conditions such as temperature and relative humidity and the volume of atmospheric air enclosed by a given cover to calculate the necessary amount of argon to achieve a desired level of relative humidity reduction. For a particular set of weather conditions, it may be necessary only to lower the relative humidity by 5%, whereas other weather conditions may dictate higher reductions, e.g. in excess of 20%.

The effective amount of argon also can be based upon a target dew point temperature rather than a reduction in relative humidity levels. Again, this is well within the skill of the artisan knowledgeable in psychometrics, various cover configurations, and venting passages associated therewith.

During the casting of aluminum-lithium alloys, the molten salt bath may be replenished by adding salt through one or more of the doors 41 in the covers 3, 11 and 17, see the sole figure. The doors 41 are closed when the argon is supplied into the respective covers. The argon gas can be supplied intermittently or continuously to achieve the desired reduction in moisture content of the atmospheric air under a given cover.

The argon flow rates can be set to preselected values as described above or can be controlled using humidity sensors in the various covers. In the latter mode, values of humidity levels in the environments under the various covers are sensed by the humidity sensors and the sensed values are relayed to a control scheme for controlling the argon gas flow rate. If humidity levels were to unexpectedly increase during a casting operation, the argon flow rate would be increased accordingly.

It should be understood that except for the inventive covers, the furnace 1, transfer station 20 and casting station 30 are representative of known casting components in the field of aluminum-lithium ingot alloy casting. As such, a further description thereof is not deemed necessary for understanding of the invention. In another aspect of the invention, the use of the inert gas-atmospheric air mixture and salt bath in the melting furnace eliminates or reduces excessive furnace wall thermitting after the casting has been completed.

In prior art methods, salt is added to the furnace during melting of aluminum-lithium scrap to keep the lithium in the bath. After fluxing and skimming of the melt prior to casting, some hydrogen regassing would occur during hot and/or humid days. In addition, since the salt bath became depleted during the casting operation, excessive furnace wall thermitting occurred after the cast when the furnace lid was opened. Upon opening the furnace lid, the furnace interior is exposed to ambient conditions which causes excessive oxidation of the furnace lining which can result in premature furnace lining failure.

In the inventive method, the molten salt bath is preferably maintained over the molten metal in the melting furnace during the casting operation. In conjunction with maintenance of the molten salt bath, the inert gas is supplied to the atmosphere in the furnace as described above. By this method, the hydrogen regassing as a result of high humidity levels in the furnace is eliminated as is furnace wall thermitting. The replenishment and maintenance of the salt bath during the casting operation produces a molten salt coating which prevents or retards furnace wall lining oxide formation upon exposure to ambient conditions when the cast is terminated and the furnace lid is opened.

In a preferred embodiment, the flow rates of argon gas in the ingot head are set at 80 to 90 SCFM. The argon flow in the melting furnace is around 30 SCFM during start up, i.e. about 5 minutes, and then reduced to about 15 to 20 SCFM. The argon flow in the pour trough cover is also around 15 to 20 SCFM. Again, it should be understood that the argon flow rates can vary depending on the humidity levels present during casting as well as the configuration of the various covers.

As such, an invention has been disclosed in terms of preferred embodiments thereof which fulfill each and every one of the objects of the present invention as set forth hereinabove and provides a new and improved method and apparatus for casting aluminum-lithium alloys.

Of course, various changes, modifications and alterations from the teachings of the present invention may be contemplated by those skilled in the art without departing from the intended spirit and scope thereof. Ac-

cordingly, it is intended that the present invention only be limited by the terms of the appended claims.

Claims

1. A method of melting and casting aluminum-lithium alloys (23) using molten salt bath (25,27) wherein an effective amount of inert gas is supplied to a moisture-containing ambient atmospheric gas (31, 35) in contact with said molten salt bath (25, 27) to reduce pick up of moisture by said molten salt bath (25, 27).

2. The method of claim 1 wherein said molten salt bath (25, 27) is utilized during at least one of the steps of melting said aluminum-lithium alloy (23), of transferring said molten aluminum-lithium alloy (23) to a casting station (30), and of casting said aluminum-lithium alloy (23).

3. The method of claim 2 wherein said inert gas is supplied after initiation of casting of said aluminum-lithium alloy (23).

4. The method of claim 1 wherein supplying said effective amount of inert gas reduces the relative humidity of said moisture-containing atmospheric gas (31, 35) by at least 5%.

5. The method of claim 4 wherein said relative humidity is reduced by at least 10%.

6. The method of claim 2 wherein said molten salt bath (25, 27) is replenished during at least one of said melting, said transferring and said casting steps.

7. The method of claim 1 wherein the moisture-containing atmospheric gas (31, 35) is contained in a cover (3, 11, 17) arranged over said molten salt bath (25, 27).

8. The method of claim 7 wherein a portion of said moisture-containing atmosphere gas (31, 35) is purged from said cover (3, 11, 17) during said supplying of said inert gas.

9. The method of claim 1 wherein said inert gas is argon.

10. Apparatus for melting and casting of aluminum-lithium alloys (23) according to claim 1, said apparatus having a melting furnace (1), a casting station (30) and a transfer arrangement (20) between said melting furnace (1) and casting station (3), and means for providing a molten salt bath (25, 27) on said molten aluminum-lithium alloy (23) in at least one of said melting furnace (1), said transfer arrangement (20) and said casting station (30), wherein said apparatus comprises means for supplying an effective amount of an inert gas to moisture-containing ambient atmospheric gas (31, 35) in contact with said molten salt bath (25, 27) to reduce moisture pick up by said molten salt bath (25, 27) by reducing the relative moisture content of said atmospheric gas (31, 35).

11. The apparatus of claim 10 wherein said means for supplying further comprises a cover (3, 11, 17) over at least one of said melting furnace (1), said transfer arrangement (20) and said casting station (30) and piping (29, 33, 37) for supplying said inert gas to said cover (3, 11, 17), said cover (3, 11, 17) being vented to atmosphere.

12. The apparatus of claim 10 further comprising means (29, 33, 37) for supplying said inert gas after initiation of casting of said aluminum-lithium alloys (23).

13. The apparatus of claim 10 further comprising a cover (3, 11, 17) over each of said melting furnace (1), said transfer arrangement (20) and said casting station (30).

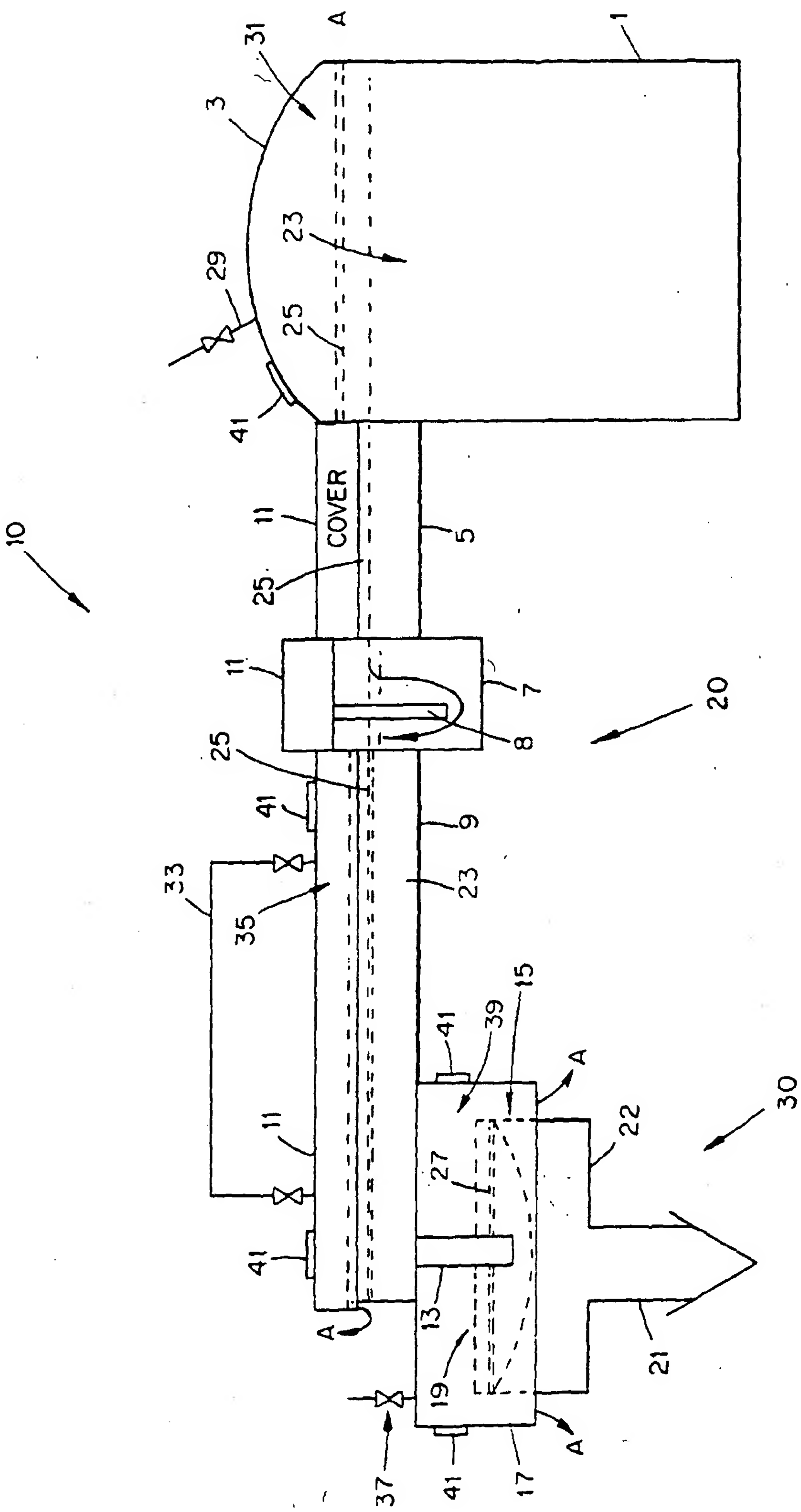
14. The apparatus of claim 11 wherein said cover (3, 11, 17) has at least one door (41) therein for replenishing said molten salt bath (25, 27).

15. The apparatus of claim 13 wherein each said cover (3, 11, 17) has at least one door (41) therein for replenishing said molten salt bath (25, 27).

16. The apparatus of claim 10 wherein said inert gas is argon.

17. An aluminum-lithium ingot made by the method of claim 1.

18. An aluminum-lithium ingot made by the method of claim 3.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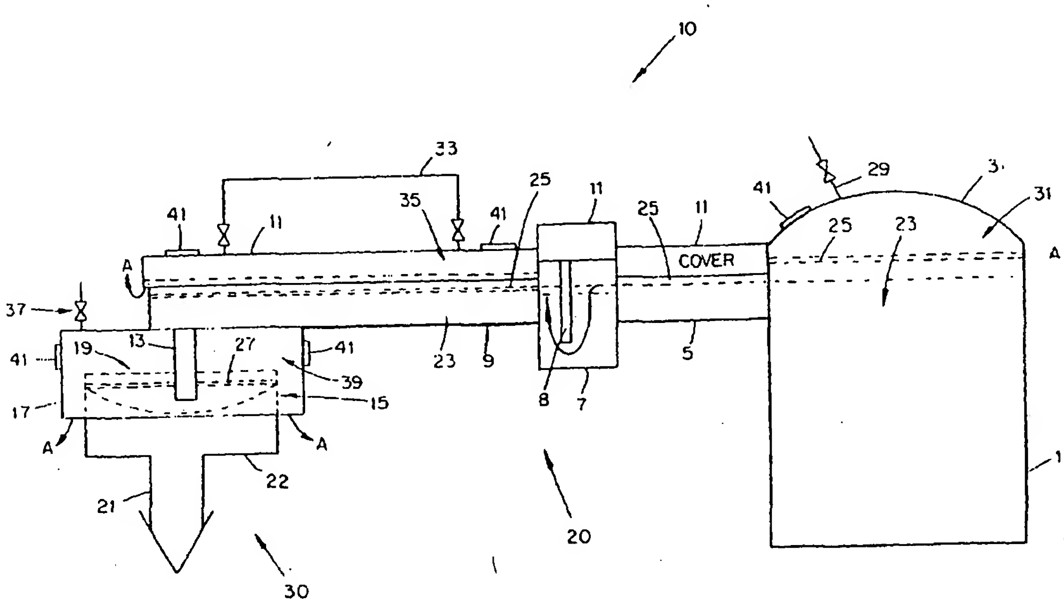

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EUROPEAN SEARCH REPORT

Application Number
EP 96 10 1738

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	EP 0 268 841 A (AIR PRODUCTS AND CHEMICALS, INC.) * page 2, column 1, line 4 - line 9 * * page 3, column 3, line 50 - line 58 * * page 3, column 4, line 5 - line 10 * * page 3, column 4, line 15 - line 20 * * page 3, column 3, line 30 - line 32 * ---	1-9,17, 18 10-13,15	B22D11/10 C22B21/06
Y	GB 1 181 518 A (PERRY J., FAIRBANK L. H., CHILDS K.) * page 2, line 114 - line 121 * * figure 1 * ---	10-13,15	
P,X	DATABASE WPI Section Ch, Week 9629 Derwent Publications Ltd., London, GB; Class M26, AN 96-285548 XP002033836 & RU 2 048 568 C (KOMAROV S B) , 20 November 1995 * abstract * ---	1-14, 16-18	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	US 4 556 535 A (BOWMAN K. A., JACOBY J. E., FINN K. M.) * column 1, line 22 - line 25 * * figure 2 * ---	1-12, 16-18	B22D C22B
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 June 1997	Peis, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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